

EX PARTE OR LATE FILED  
LAW OFFICES  
LEVENTHAL, SENTER & LERMAN P.L.L.C.  
SUITE 600

ORIGINAL

NORMAN P. LEVENTHAL  
MEREDITH S. SENTER, JR.  
STEVEN ALMAN LERMAN  
RAUL R. RODRIGUEZ  
DENNIS P. CORBETT  
BRIAN M. MADDEN  
BARBARA K. GARDNER  
STEPHEN D. BARUCH  
SALLY A. BUCKMAN  
NANCY L. WOLF  
DAVID S. KEIR  
DEBORAH R. COLEMAN  
NANCY A. ORY  
ROSS G. GREENBERG  
H. ANTHONY LEHV  
JOHN D. POUTASSE  
CHRISTOPHER J. SOVA  
PHILIP A. BONOMO  
JUAN F. MADRID  
JANET Y. SHIH  
JENNIFER A. MERRILL

2000 K STREET, N.W.  
WASHINGTON, D.C. 20006-1809

TELEPHONE  
(202) 429-8970

TELECOPIER  
(202) 293-7783

February 26, 2001

WWW.LSL-LAW.COM

VIA HAND DELIVERY

RECEIVED

FEB 26 2001

ORIGINAL

FEDERAL COMMUNICATIONS COMMISSION  
OFFICE OF THE SECRETARY

Ms. Magalie R. Salas, Secretary  
Federal Communications Commission  
445 12<sup>th</sup> Street, S.W.  
Washington, D.C. 20554

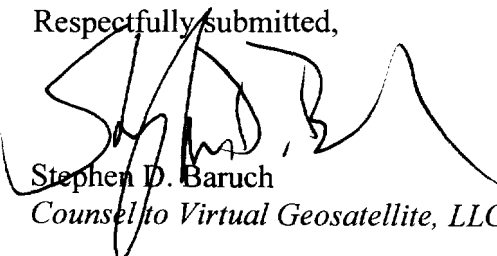
Re: Notification of Ex Parte Presentation in ET Docket No. 98-206

Dear Ms. Salas:

Pursuant to Section 1.1206 of the Commission's Rules, 47 C.F.R. § 1.1206, this letter serves as notice that on February 23, 2001, representatives of Virtual Geosatellite LLC ("Virtual Geo") met with the International Bureau staff members copied below to provide answers to questions concerning Virtual Geo's proposal for a regulatory definition for virtual geostationary satellite orbit systems and networks. The materials are associated with Virtual Geo's proposal for an assignment plan to accommodate non-geostationary ("NGSO") fixed-satellite service ("FSS") systems in the Ku-band frequencies made available and designated for NGSO FSS use in the *First Report and Order* in ET Docket No. 98-206. The attached materials were presented and provided to the attendees. Virtual Geo was represented at the meeting by Gerald Helman, Jay Brosius, Raul R. Rodriguez and Stephen D. Baruch.

The original and one copy of this letter are submitted for inclusion in the record of the referenced proceeding.

Respectfully submitted,

  
Stephen D. Baruch

Counsel to Virtual Geosatellite, LLC

Attachment

cc (w/ att, by e-mail.): Thomas S. Tycz

Cecily Holiday

Karl Kensinger

Jennifer Gilsenan

No. of Copies rec'd 071

LISTABODE

LEVENTHAL, SENTER & LERMAN P.L.L.C.

Ms. Magalie R. Salas, Secretary  
February 26, 2001  
Page 2

Paul Locke  
John Martin  
Alex Roytblat  
Persaud Sankar  
Bruno Pattan

148312.1

# Responses to Questions Regarding VGSO

23 February 2001

1. Give a brief description of [table items] 1 – 7 [in the handout of last week, see Table 4 below].

2. Explain why you picked the numbers that are in the table, where there is flexibility to choose other numbers, and where there is not flexibility..or very little flexibility, why that is the case.

a. Mean Motion: The number of revolutions around the earth the satellite makes in 1 day.

An integer value of mean motion ensures that the satellite will repeat the same ground track each day. Since we want all satellites to follow a repeating ground track, and wanted each satellite to visit no more than 3 active arcs, we selected an integer mean motion of 3, rather than a rational mean motion, which would have yielded repeating ground tracks at intervals longer than one day.

A mean motion of 4 yields 4 active arcs per ground track and active arcs that are too broad to maintain the regional geographic coverage that we desired.

A mean motion of 2 yields 2 active arcs per ground track, and very narrow active arcs. Slotting along an active arc here is less feasible, since positions on the active arc are not well separated in angle. Also, its apogee altitude is high, being around 38,500 kilometers, leading to high latency. This uses the well-known Molniya orbit.

b. Inclination: 63.435 degrees. This figure prevents the line of apsides, the line connecting the apogee and perigee, from rotating around the orbit, moving the apogee southward toward the equator. If the inclination is higher, the line of apsides will rotate in a direction opposite to the direction of satellite motion. If lower, the line of apsides will rotate around the orbit in the same direction as satellite motion.

c. Eccentricity 0.63 - 0.66. The latter value is the maximum feasible value, which, when combined with the necessary mean motion, yields an apogee of 27,271 kilometers, and a perigee of 513 kilometers. While there is some small amount of drag at perigee, orbit lifetimes are expected to be well into the 10s of years, since most of the orbit is spent much higher. A lower eccentricity will yield lower apogees, higher perigees and even less atmospheric drag and LEO orbit intersection, but slightly lower declinations (angle above the equator from the center of the earth) for the lowest part of the active arcs, per Table 1. The number of satellites that can be placed simultaneously in an active arc will

increase slightly, but coverage areas may also slightly reduce, due to lower operational satellite altitudes at active arc end points.

**Table 1, The Effect of Eccentricity on Orbital Parameters**

<b>Eccentricity</b>	<b>Declination of lowest point in active arc, degrees</b>	<b>Apogee, kilometers</b>	<b>Altitude of ends of arcs, km</b>	<b>Perigee, kilometers</b>
0.66	46.02	27,271	18,025	513
0.65	45.34	27,068	17,863	716
0.64	44.64	26,865	17,702	919
0.63	43.95	26,680	17,544	1,122

An eccentricity value in the above range may be chosen with relatively little effect on HLSA characteristics and advantages. Even lower eccentricities move the lower ends of the active arcs closer still to the equator, and become increasingly less desirable. Changes in eccentricity have a more dramatic effect on perigee than any other factor, hence the advantages of an increased perigee may push the favored orbit toward the lower eccentricity of around 0.63.

d. Argument of Perigee: 270 degrees for northern groundtracks and 90 degrees for southern groundtracks. These values are important as they determine where the apogees are, where satellite motion is slowest. These figures place the apogees at the furthest angles in declination from the equator, and keep the active arcs, which span 216 degrees of Mean Anomaly, well separated from the equatorial arc. As the Argument of Perigee departs from these values, the ends of the active arcs will move toward the equator. Some slight variation in argument of perigee from the cited value, on the order of one degree, might be desirable to ensure good satellite spacing at orbit crossings, depending on the results of further analyses. Otherwise little flexibility exists in these numbers.

e. Longitude of Apogees: This measure specifies where the peaks of the active arcs are located over the surface of the earth in coordinates relative to the rotating earth. For a Mean Motion of 3, a satellite's ground track will pass through three apogee longitudes, spaced 120 degrees from each other in longitude. Therefore, for a given ground track, specifying one Longitude of Apogee specifies the other two as well. For convenience therefore, specifying the location of the active arcs in the region from 0 degrees West Longitude to 120 degrees West Longitude is sufficient to locate a ground track in any Longitude orientation. This range may be termed the Americas Sector (the others may be termed the EurAsian Sector and the Pacific Sector).

A given ground track may have any Longitude of Apogee in this 0-120 degree range. Good coverage of important markets may be an important criteria for selecting the locations of the Longitude of Apogees. The second ground track should have an Apogee of Longitude that places the active arcs between those of the first, without crossing and maintaining a good separation from those of the first. Once the location of the first active Arc is located, the second may be placed 60 degrees in Longitude from the first, or slightly more or less, depending on desired coverage versus active arc separations.

f. Active Arc Span: 2 hours and 24 minutes (or 108 degrees of Mean Anomaly) to each side of apogee, plus x minutes per side for housekeeping, switchover. The ratio of active satellites to total satellites per ground track per system determines this span. This choice derives from 3 active satellites and 5 total satellites per ground track. It is however possible to design a VGSO arrangement using 3 active arcs one active satellite per arc, and 4 total satellites rather than 5. In this case the active arcs extend down to 28 degrees North declination at a minimum operational altitude of around 11,900 kilometers rather than the 17,500 - 18,000 kilometers of the present design. The satellites would have to cope with a greater variation in orbital altitude, but would be in operation for 75 percent of the time each. Coverage areas will reduce, since the extensions of the active arcs are at relatively low altitudes, keeping in mind that the service area must have good satellite visibility from all points in the active arc, including the furthest, lowest limb.

g. Mean Anomaly at epoch: selected to place each satellite at an appropriate interval from its neighbor. The absolute number is not so important here as the relative MA. Absolute MA will determine when the satellite passes a point on the earth. Relative MA will determine the separations among satellites. Mean Anomaly spacing and minimum included zenith angles of the satellites are related as shown in Figure 2 shown later.

### 3. What numbers have to be standardized in order to realize the advantages of VGSO?

In order to realize the advantages of VGSO, the FCC should standardize the parameters shown in Table 2:

**Table 2, Parameters to be Standardized**

<b>Parameter</b>	<b>Suggested Value</b>
Mean Motion	3 (semimajor axis = 20,270.421 km)
Eccentricity	In range of 0.66 to 0.63 (0.64, 0.63 attractive)

Parameter	Suggested Value
Inclination	63.435 degrees, or that required to stop apsidal rotation
Longitudes of Apogees	65 and 125 degrees W Longitude in Americas Sector. Further study may suggest other locations
Argument of Perigees	270 degrees for Northern HLSAs; 90 degrees for Southern HLSAs
Active Arc extents (may be specified as degrees of Mean Anomaly in orbit)	108 degrees (plus 3 degrees housekeeping) of MA each side of apogee
Index position in each ground track, defined as a Mean Anomaly at a cited epoch, from which all satellite positions are to be measured.	0 degrees MA at January 1, 2005
Spacing in ground track (in Mean Anomaly, or alternatively, time of cited point crossing) for each service type to be authorized	15 degrees MA (14 at $e = 0.63$ )
Required minimum earth station antenna pattern characteristics for each such spacing or corresponding service	per existing FSS for 2 degree spacing
Orbital maintenance tolerances: In track Cross-track Altitude	as later determined to be necessary
Downlink power limits when in HLSA	Per FCC and ITU rules
Emission attenuation (or maximum eirp or epfd) when outside HLSA	[TBD]

**4. How many ground tracks are associated with each [HLSA]? How many HLSA/ground tracks each satellite would have to occupy in order to provide global coverage? How many satellites in all?**

Each High Latitude Stationary Arc (HLSA) is one active arc on one groundtrack. Each ground track has three HLSAs. A system may provide substantial Northern Hemisphere coverage from 5 satellites in one Northern HLSA ground track, providing service from the equator northward everywhere under the active arc. At the worst-case Longitude

exactly between active arcs of the one ground track, coverage from a single ground track begins North of 30 degrees North. Coverage of the Southern Hemisphere is similar, using a single Southern HLSA ground track. A system may achieve global coverage pole to equator to pole using two Northern and one Southern ground tracks and 15 satellites (of which 9 are active at any one time), given appropriate HLSA placements. A total of four ground tracks are available for use, and if a system elects to use all of them, it will deploy 20 satellites, of which 12 will be active at any given time. It will thereby obtain good, continuous, pole-to-pole global coverage.

Services offered by many prospective operators will concentrate on regional markets, or for example on markets primarily on land-masses. Ground track occupancy and visibility requirements can be reduced in that case. An operator seeking to service specific regions would place satellites in the ground tracks with active arcs serving those regions. A consortium of operators may share in the development, construction, and launch costs of satellites serving a particular ground track and its three HLSAs. Since each satellite visits all active arcs in the ground track, a satellite loss is spread over three markets rather than one, and results in a 20 percent time-outage rather than a 100 percent outage. Sparing is cheaper (e.g., 1 for 5 rather than 1 for 1), risk is spread over several operators (similar to an insurance pool), and loss consequences are less drastic. VGSO deployments are therefore also well suited to regional services.

**5. Based on virtual “two degree spacing”, how many satellite systems could be accommodated. Is two the right number? Would smaller or larger “spacing” be preferable?**

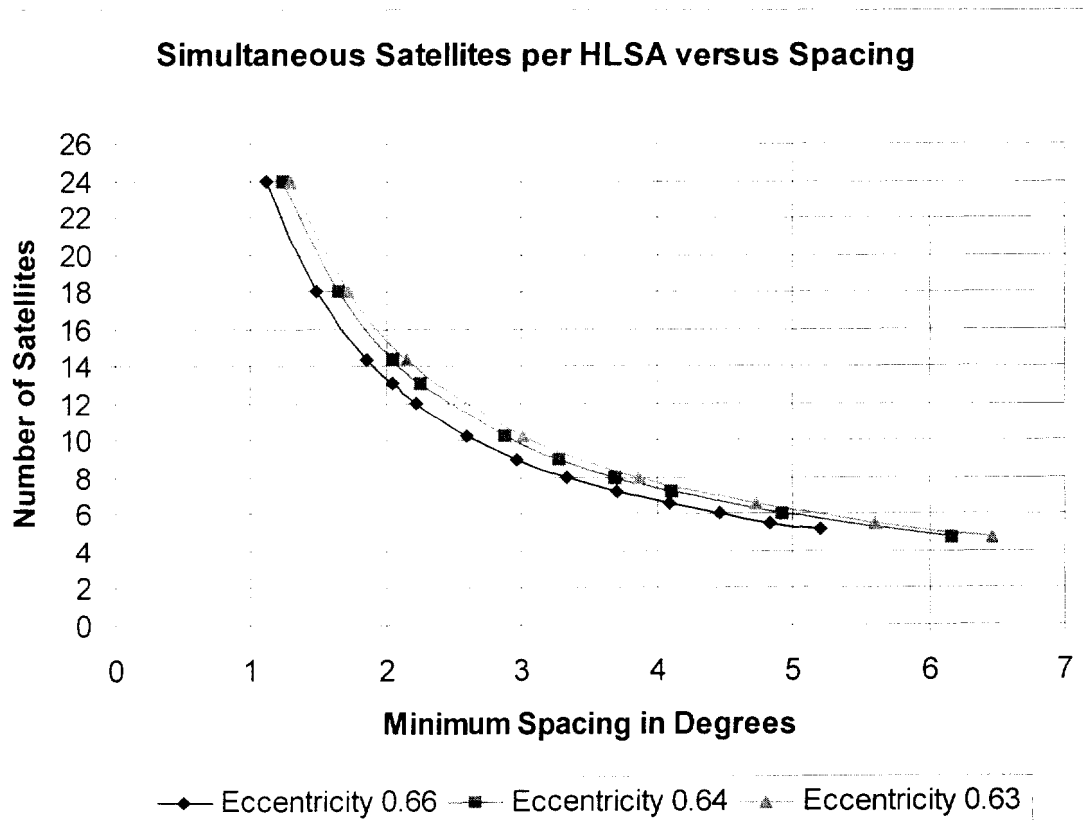
Figure 1 presents the number of satellites that can be accommodated in each HLSA of each ground track. Each satellite may belong to a different system. If a given system requires only one ground-track and places an active satellite in each of the three HLSAs, each ground track would, for example, accommodate 14 or 15 satellites per ground track (for  $e = 0.64$  and  $0.63$  respectively) at a minimum required 2 degree included zenith angle between satellites (measured from the earth’s center through the satellite, more may be accommodated if measured from the surface of the earth). With four ground tracks, the VGSO allocation scheme can accommodate 56 ( $e=0.64$ ) or 60 ( $e=0.63$ ) systems, each with a satellite at all times in each of three HLSAs. Each such system may moreover be viewed as equivalent to three regional systems, one per satellite per HLSA, for a total of 168 ( $e=0.64$ ) or 180 ( $e=0.63$ ) distinct regional operations possible, using a total of 280 ( $e=0.64$ ) or 300 ( $e=0.63$ ) satellites.

In summary (with  $2^\circ$  spacing and  $e=0.63$ ):

- 5 satellites in 1 ground track yield full time service in each of 3 HLSAs in the ground track, with 1 satellite per HLSA (the other 2 satellites are in transit between HLSAs)
- Each HLSA will accommodate 15 satellites simultaneously
- Each ground track therefore accommodates  $15 \times 5 = 75$  of which  $15 \times 3 = 45$  are active

- 4 ground tracks therefore accommodate  $4 \times 75 = 300$  satellites of which  $4 \times 45 = 180$  are active worldwide.
- This represents potentially 30 full global (N & S), 60 hemispheric (N or S), or 180 regional systems.

Additional technical studies will be required to determine whether a 2 degree spacing is optimum for VGSO operations. A number of variables, such as the antenna beam tracking technique chosen, for example, may affect minimum spacing choices, but two degrees is an appropriate starting point.



**Figure 1, Simultaneous Satellites Possible**



**6. Explain in writing what the Commission would be granting in a license.**

In granting a license for a VGSO assignment, the Commission would be assigning satellite deployment parameters as described in Table 2, Parameters to be Standardized, above, plus an authorized service and authorized spectrum. In addition, the Commission assigns a position within a ground track to a licensee, defined as a Mean Anomaly relative to the index position. The Commission may wish to grant assignments in units of 5 satellites in one ground track evenly spaced by 216 degrees in Mean Anomaly from each other, the first of which maintains the specified Mean Anomaly relative to the index position. This assignment places one satellite at all times in each of the three HLSAs of the one ground track; the other satellites are in transit between HLSAs. As above, 14 or 15 such assignments are possible per ground track given 2-degree spacing. The Space Station would be licensed to operate in each HLSA of the ground track. Licensees would require individual licenses for each gateway and blanket licenses for user terminals as appropriate.

**7. What is the minimum amount of spectrum that VGSO would need to provide the type of service you envision? Why?**

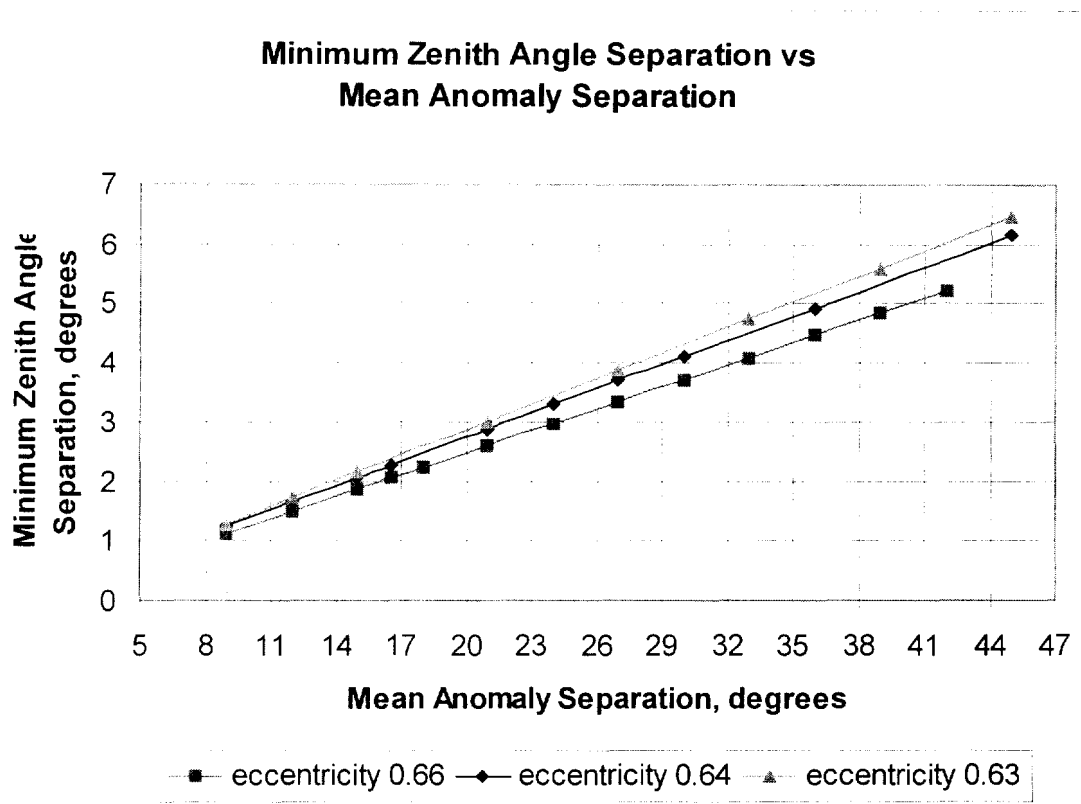
VGSO, like traditional GSO or NGSO, is a category of space platform that can be associated with a variety of services, and will facilitate the provision of any number of broadband and related applications. The amount of spectrum necessary for VGSO systems will thus vary to some degree based on such factors as the frequency bands involved, the service to be provided, and the business plans of the individual applicants.

For Virtual Geosatellite, LLC, which is seeking to use the newly-allocated and designated non-GSO FSS spectrum at Ku-band, the minimum amounts of spectrum required to establish the type of VGSO system it contemplates are as Virtual Geosatellite presented to the Commission in its January 19, 2001 *ex parte* presentation of an Ku-band assignment plan proposal. The table from that presentation, which contains the applicant's proposal for VGSO zones and Growth zones, is attached to these responses as Table 3.

**8. For an eccentricity of 0.66, please provide a curve that relates the difference in the mean anomaly between two satellites to the minimum difference in the true anomaly of the satellites. Please cover the difference in true anomaly from 0 to about 5 degrees. Please provide the specific calculation that leads to a two degree "spacing" and a definition of "spacing" in orbital mechanic terms (such as true anomaly).**

Figure 2 relates Mean Anomaly difference to the minimum included zenith angle of adjacent satellites for two different eccentricities. Note that differences in True Anomaly are normally defined within the same orbit, which is not the case here. Hence, while it is acceptable to assign slots based on Mean Anomaly differences, minimum included zenith angle (the angle between two satellites measured from the center of the earth) is a more accurate measure of satellite separation than true anomaly difference, since the former also accounts for orbit plane separation angles. Included zenith angle refers to the angle

between vectors to each satellite from the center of the earth. True anomaly refers to the differences in position along a single orbit. Included zenith angle includes true anomaly plus differences in the right ascension of the ascending nodes of two differing orbit planes.

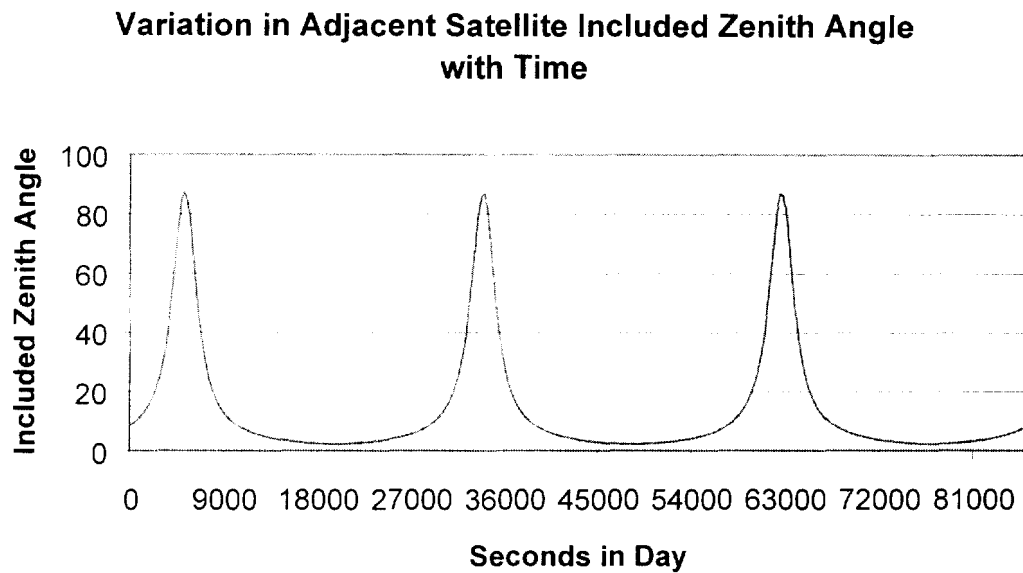


**Figure 2, Minimum Satellite Separation versus Mean Anomaly**

Figure 3 illustrates the variation in included zenith angle with time between two adjacent satellites spaced at 2 degrees at apogee. The time spent in the HLSA is in the flat low-valued region, whereas the peaks represent satellite passage through perigee, when they separate widely and are inactive.

True Anomaly, which is related to included zenith angle as mentioned above, cannot be calculated in closed form from Mean Anomaly, since Mean Anomaly is expressed as a transcendental function of true anomaly, and the equation cannot be inverted to solve for TA. Numeric techniques are often used for this purpose, and were used (via orbital analysis software) to derive the values in included zenith angle in this paper. In practice, both the mean anomaly (MA) and right ascension (RAAN) differences between two satellites were varied (together so as to maintain a common ground track) while examining the worst case separation angle (as shown in the chart below, but done

numerically) until those MA and RAAN values were found that yielded the desired included zenith angle.



**Figure 3, Variation in Included Zenith Angle with Time between Two Satellites**

**Table 3**

**VIRTUAL GEO Ku-BAND ASSIGNMENT PLAN PROPOSAL**

**GATEWAY UPLINK BANDS**

**12.75-13.15 GHz and 13.2125-13.25 GHz**

		<b><u># MHz</u></b>
VGSO Zone	12.75-12.960 GHz	210
Growth Zone	12.960-12.9775 GHz	17.5
Non-VGSO Zone	12.9775-13.15 and 13.2125-13.25 GHz	210

**13.75-14.0 GHz**

		<b><u># MHz</u></b>
VGSO Zone	13.75-13.865 GHz	115
Growth Zone	13.865-13.885 GHz	20
Non-VGSO Zone	13.885-14.00 GHz	115

**USER UPLINK BAND**

**14.00-14.50 GHz**

		<b><u># MHz</u></b>
VGSO Zone	14.00-14.24 GHz	240
Growth Zone	14.24-14.26 GHz	20
Non-VGSO Zone	14.26-14.50 GHz	240

**GATEWAY DOWNLINK BAND**

**10.7-11.7 GHz**

		<b><u># MHz</u></b>
VGSO Zone	10.70-11.175 GHz	475
Growth Zone	11.175-11.225 GHz	50
Non-VGSO Zone	11.225-11.70 GHz	475

**USER DOWNLINK BAND**

**11.7-12.7 GHz**

		<b><u># MHz</u></b>
Non-VGSO Zone	11.70-12.175 GHz	475
Growth Zone	12.175-12.225 GHz	50
VGSO Zone	12.225-12.70 GHz	475

**SPECTRUM TOTALS:**

<b><u>ZONE TYPE</u></b>	<b><u>GATEWAY UP</u></b>	<b><u>GATEWAY DOWN</u></b>	<b><u>USER UPLINK</u></b>	<b><u>USER DOWNLINK</u></b>	<b><u>TOTAL</u></b>
VGSO Zone	325 MHz	475 MHz	240 MHz	475 MHz	1515 MHz
Growth Zone	37.5 MHz	50 MHz	20 MHz	50 MHz	157.5 MHz
Non-VGSO Zone	325 MHz	475 MHz	240 MHz	475 MHz	1515 MHz

**Table 4, Parameters Submitted February 15, 2001**

1. Mean Motion	3 (yielding 3 active arcs equally spaced in longitude around the Earth)
2. Inclination:	63.435° to ensure fixed apogees in a posigrade orbit
3. Eccentricity:	0.66
4. Argument of perigee:	270° for Northern arcs, and 90° for Southern arcs
5. Longitude of Apogees:	Fixed for all satellites to avoid crossings of HLSSAs; adjacent ground tracks must be separated by an angle of nominal value of approximately 60° (see Note)
6. Active Arc Span:	Nominal 2 hours and 24 minutes to each side of apogee plus x minutes for housekeeping and handover at activation and deactivation on each end, for a total of 4 hours and 48 minutes plus 2x minutes duration in the active arc
7. Mean Anomaly:	As needed to achieve minimum desired active arc angular spacing (15° increments produce approximately 2° minimum active arc spacing)

## DEFINITION OF VIRTUAL GEOSTATIONARY SATELLITE ORBIT

### 1. Add New Subsection (g) to New Section 25.146:

#### **25.146 Licensing and operating authorization provisions for the non-geostationary satellite orbit fixed-satellite service (NGSO FSS) in the bands 10.7 GHz to 14.5 GHz.**

\*\*\*\*\*

(g) In the frequency bands A-B GHz, X-Y GHz, C-D GHz and P-Q GHz, operation of NGSO FSS systems and networks shall be limited to virtual geostationary satellite orbit systems and networks.

### 2. Add New Definition to Section 25.103:

(g) *Virtual Geostationary Satellite Orbit (VGSO) System/Network.* A non-geostationary satellite system or network in which satellites in “virtual slots” (see Note) transmit or retransmit radiocommunication signals only while within a region of space located at high latitude (either Northern or Southern) that rotates synchronously with the Earth (one rotation per day) and while separated from the geostationary-satellite orbit by at least 40°. In order to be included within a VGSO system or network, a satellite must move in a sub-geosynchronous orbit characterized by the following parameters:

Mean Motion:	3 (therefore ground tracks can be centered around 3 longitudinal locations on Earth)
Inclination:	63.435° to ensure fixed apogees and posigrade orbits
Eccentricity:	0.66
Argument of perigee:	270° for Northern arcs, and 90° for Southern arcs
Active Arc Span:	Nominal 2hrs 30 minutes at each side of apogee for a total of 5hrs
Longitude of Apogees:	65° and 125° for each ground track in each hemisphere
Semi-major axis:	22,250 km - 20,300 km (derived from Mean Motion and Eccentricity above)
Relative Mean Anomaly:	for 2° spacing, at least -15° relative to the preceding satellite (see Note)
Relative RAAN:	for 2° spacing at least 5° relative to the preceding satellite” (see Note)

*Note:* A “virtual slot” is the angular interval of longitude required to achieve at least 2° spacing (or another value set by regulation) for the ground central angle. In order to achieve this value and therefore maintain a common ground track for all satellites, the Mean Anomaly and RAAN for each satellite must be defined relative to a first assigned “virtual slot”, say one centered near mid CONUS. These two values are then coordinated and defined as a pair of parameters. For a given angular separation  $\theta$ , ( $\theta$  being, e.g., 2°), the time for a satellite to travel  $\theta^\circ$  at apogee being  $t_0$ , and the orbital period being  $P$  (in seconds), the relative Mean Anomaly is:

$$\text{Rel. MA} = -360 \times t_0 / P \quad \text{for } \theta = 2^\circ, \text{ Rel. MA} = -15^\circ,$$

And the relative Right Ascension of Ascending Node is:

$$\text{Rel. RAAN} = 360 \times t_0 / 86,400 \quad \text{for } \theta = 2^\circ, \text{ Rel. RAAN} = +5^\circ$$